Space Weather Technical Forecast

Issued on Sunday, 21 May 2023 at 01:29 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: R1/R2 radio blackouts expected throughout with a chance of High activity. Chance of G1/Minor Geomagnetic Storms between 21 and 23 May.

Analysis of Space Weather Activity over past 24 hours
Solar Activity: Solar activity has been High over the last 24 hours, with a peak flare of M8.9 at 20/1235UTC from AR3311, a complex region in the northeast quadrant, which has developed a pair of delta spots. This region has produced four M-class flares in total and was responsible for much of the solar activity. AR3312, a region on the southeast limb has also shown developments, but remains as a beta region. AR3305 has a history of flare activity, but has been relatively inactive. AR3310 has not produced any flare activity, but has been developing into a beta region. The remaining four regions are either weak or only developing slowly.
A CME which left the Sun around 20/0605UTC is being analysed for an Earth-directed component. No further CMEs have been observed.

Solar Wind / Geomagnetic Activity: The solar wind, as measured at L1 has been indicative of a CIR (co-rotating interaction region and possible high speed stream connection, perhaps from coronal hole 03. Solar wind speeds increased from 350km/s to average at around 630km/s. Density started initially above average at 16ppcc, but has steadily subsided to 9ppcc. Total magnetic field strength started strong at around 20nT, but has weakened, reaching 5nT by the end of the period. The north-south component, Bz, was initially strongly negative, at -17nT, but eased to near neutral levels during the day. Phi angle was manly negative (towards the Sun), but was briefly positive between 20/2000UTC and 20/1000UTC. Geomagnetic activity reached G2 (Kp5) levels between 20/0000-0300, and was at G1 (Kp5) levels between 20/0300-1200UTC, but was Unsettled after this time.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as measured at GOES16 has remained at background levels throughout.
High energy electron flux (greater than 2MeV), as measured at GOES16 was at background levels. The 24-hour integrated fluence has been well below Active levels. At 21/0001UTC, 2.16e6 integrated pfu was recorded.

Four-Day Space Weather Forecast Summary
Solar Activity: Solar activity is expected to be mainly Moderate, with a chance of High activity, due to either multiple M-class flares, or a chance of X-class flares. The main risk region is AR3311 in the northeast quadrant, which has produced multiple M-class flares and continues to develop in complexity. Other regions in the southeast and northwest also present a heightened flare risk.

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Met Office Space Weather Technical Forecast

Solar Wind / Geomagnetic Activity: A CME which left the Sun on 17 May, may glance the Earth on 21 May, but with relatively low confidence. Further CMEs are under analysis for Earth-directed components, including an eruption from the southwest quadrant early on 21 May.
Solar winds from coronal hole 03 are expected to decline later on 21 May, but perhaps will not reach ambient levels. An increase is then possible either later 22 or more likely 23 May, due to a high speed stream from coronal hole 06 with speeds of 500-600km/s possible.
Geomagnetic activity is expected to start Quiet to Unsettled on 21 May, becoming Unsettled to Active due to the possible effects of the CME, with a risk of G1/Minor Storms. Further effects are possible during 22 and 23 May due to the residual CME effects and the connection to a coronal hole high speed stream.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux carries a daily slight chance of S1, largely as a result of the eastern hemisphere spots, with this very gradually rising over the four days.
High energy electron flux (greater than 2MeV) will most likely remain at background levels throughout, with electron fluence remaining below the Active (1e8 integrated pfu) threshold.

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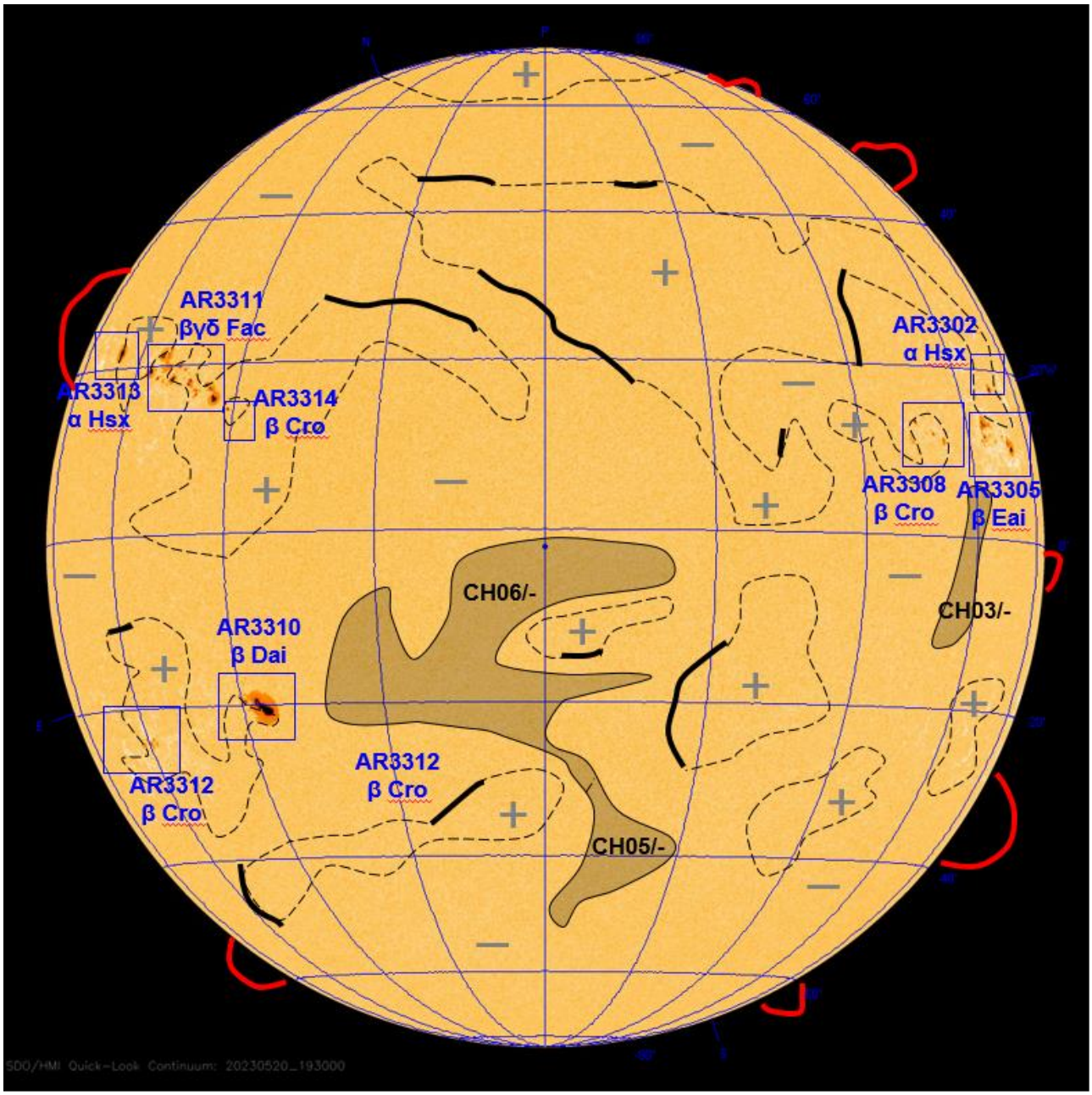
Figure 1. Solar Analysis Valid 20/2000UTC.



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Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A period of geomagnetic storming occurred early on 20 May. This appears to be due to the connection with recurring coronal hole 03. Although this coronal hole exhibits a similar appearance to the last rotation, resultant geomagnetic activity appears to have been masked by concurrent CME activity. Although on this rotation the sharp increase in density and fall in speed appear to be due to a CIR preceding the high speed stream, there is evidence that a transient CME may also be embedded in the solar wind. This evidence includes the short lag time between the feature being observed at STEREO A and Earth, and the observation of parameters at L1, which seem to indicate a shock at around 20/0400UTC which would be more consistent with a CME arrival. As the traces show both CME and solar wind characteristics, a combination of the two is considered possible, with a CME on 15 May, which was analysed but initially discount considered to be the likeliest candidate.

One CME is forecast to affect the Earth during the forecast period. This feature left the Sun on 17 May and is forecast to glance the Earth on 20 May, although the Enlil ensemble forecast suggests a wide range of solutions from around 21/1200UTC. A large coronal hole in centre disc, coronal hole 06 also presents a risk of increased activity, with speeds of 500-600km/s possible from either 22 or 23 May.

Geomagnetic activity is forecast to be mainly Quiet to Unsettled at first on 21 May, increasing to Unsettled or Active, with a risk of G1/Minor storms due to the possible CME arrival. Residual geomagnetic storms are then possible through in 22 May, due to a potential combination of CME and coronal hole enhancements. Any enhancements may then continue into 23 May due to the coronal hole effects, with a reduction in activity on 24 May.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	20	30	30	10
Strong	G3	No	1	10	10	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
18/0316	Partial	Filament eruption	Southwest	400	21/1200	Possible glancing blow.

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Figure 2: Recent solar wind parameters at L1. The 'shock' mentioned in the text is highlighted.

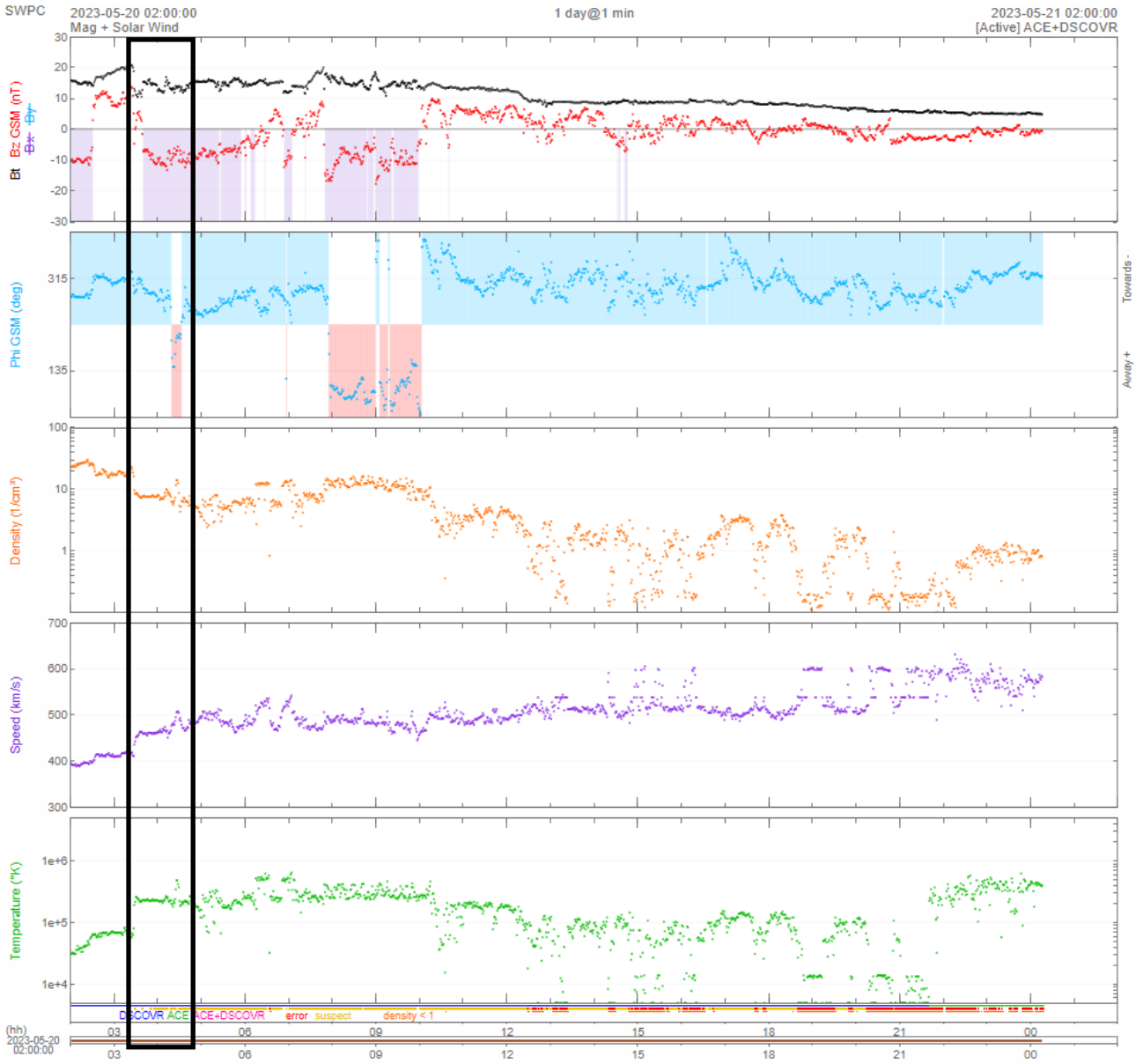

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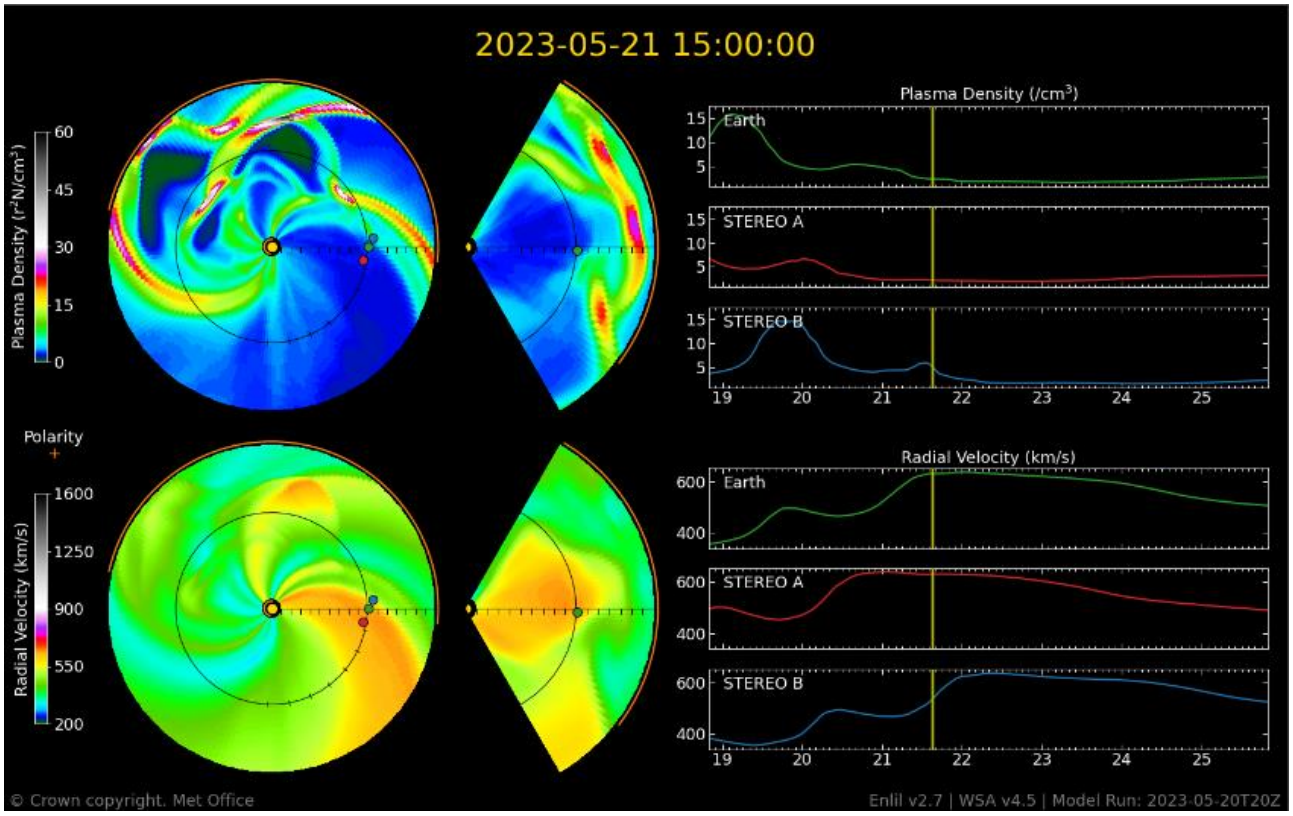
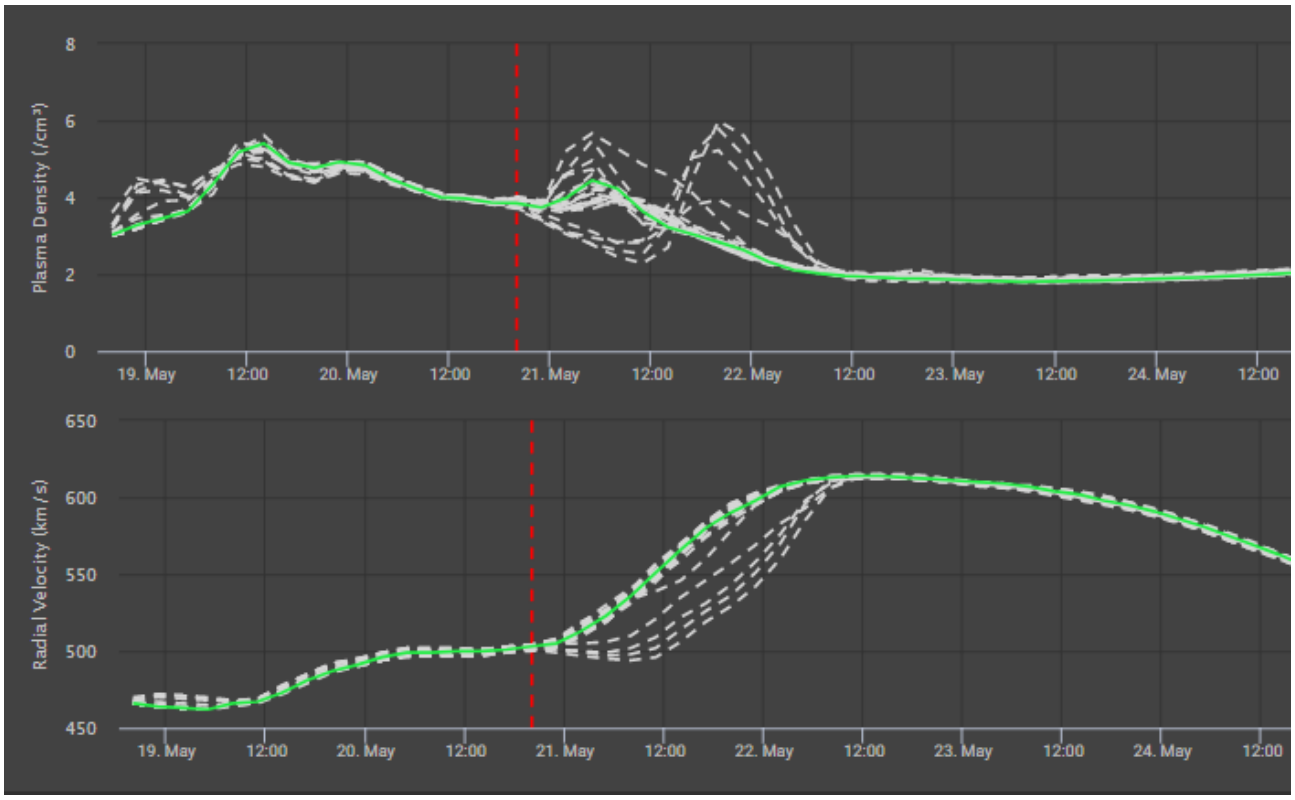
Figure 3: Enlil and Enlil ensemble models for possible CM<E glance on 21 May. The wide spread of possible arrival times is evident on the ensemble.





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Radio Blackouts - X-Ray Flares:
AR3311, a large and complex region in the northeast quadrant has developed two small but distinct delta spots within the last 24 hours, with a significant increase in activity. AR3305 appears to be declining, but is difficult to analyse due to foreshortening as it is close to the western limb. AR3112, close to the southeast limb appears to be relatively simple, but has produced an M-class flare and is starting to develop further complexity. AR3310 has developed bipolar characteristics and needs monitoring for further developments. The remaining regions are all relatively benign or only evolving slowly.

Solar activity is expected to be mainly Moderate to High, with a risk of X-class flares, especially from AR3311 in the northeast quadrant. There is a slight decrease in risk from 24 May as AR3305 rotates across the western limb.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	R1-R2 M Class	Yes	70	70	70	60
Very Active	R3 to R5 X Class	No	20	20	20	10

Figure 4: AR3311, observed in both HMI intensitygram and magnetogram imagery.

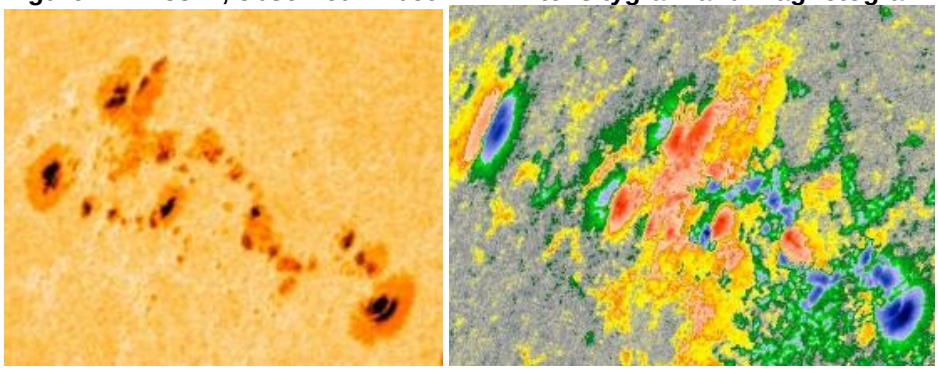

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Figure 5: GOES-16 X-ray flux

Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16 has remained at background levels throughout and is expected to remain as such throughout the period. AR3311 is currently the most likely source for any further enhancements, and to a lesser extent AR3305. The risk of high energy proton events is therefore not negligible, and increases slightly through the period as AR3311 moves into the western hemisphere.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

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High Energy Electrons Event (≥ 2MeV):
The high energy electron flux (greater than 2MeV) has remained at mainly background levels through the last 24 hours, as the strengthening of the high speed stream which would normally input electrons into the belts, is balanced by the increased geomagnetic activity which has helped to redistribute electrons. The strength of the solar wind will also help to have distorted the radiation belts from their natural orbits.

Over the next four days, there is high uncertainty in the behaviour of electron flux and consequent fluence. This is again due to the uncertainty in the possible connection with the high speed stream from coronal hole 06 and the decrease in speed from coronal hole 03.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	5	5
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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